§6. Performance Test of Direct Immersion Method to Detect Tritium in Concrete

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A tritium handling laboratory constructed at the National Institute for Fusion Science was characterized by the fact that tritium was the only radioisotope it handled. The main chemical forms were tritiated hydrogen gases (tritium gas) and tritiated water. The laboratory's role, however, came to an end, and the necessary measures that were legally required at the discontinuation of radioisotope use were completed. During these measures, tritium contamination tests of all articles, fixtures, equipment, and the building itself including walls and floors was conducted. Aside from the necessary measures taken according to the law, the performance of a direct-immersion method (Appendix 1) was evaluated to detect tritium contamination in concrete.

There are several methods to measure tritium contamination in concrete. The heating-cooling method (Appendix 1) may be the most efficient way from the viewpoint of collecting tritium in concrete pieces. However, this method is not very practical when employed after the discontinuation of radioisotope use because of the inconvenience regarding time and ease of use. For this reason, the direct-immersion method may be used as a practical measure for evaluating tritium contamination of concrete walls and floors.

In this report, the direct-immersion method was compared with the heating-cooling method. An adequate quantity of concrete was chipped from the actual walls or floors, called a lot block, and used two 1-g pieces from the same lot block as samples. These samples was measured using both the direct-immersion and heating-cooling methods.

Table 1 shows contamination measured using both methods in the order of strength of tritium contamination. On the right, ratios are listed, which were obtained by dividing the contamination measured using the heating-cooling method with that measured using the direct-immersion method. The ratios are distributed from 2 to 3, and the averaged ratio is determined to be 2.54, with a standard deviation of 7.4%. The direct-immersion method may give an estimation that is 2.5 times smaller than the heating-cooling method, and that the ratios might be used as a collection factor to convert data obtained using the direst-immersion method to that of the heating-cooling method.

Table 1 Comparison between heating-cooling method and direct immersion method

Position Number	Heating-cooling Method (Bq/g)	Direct Immersion Method (Bq/g)	Ratio
1	69.3	27.2	2.55
2	27.7	11.0	2.52
3	10.8	4.8	2.25
4	7.95	2.8	2.80
5	6.03	2.0	3.07
6	4.67	2.0	2.37
7	3.69	1.5	2.49
8	3.21	1.4	2.28
	Average (except asterisked data)		2.54 (7.4%)

Appendix 1(direct-immersion method)

To measure tritium contamination in the concrete structure itself, a 1-g piece of concrete chipped from the wall or floor was placed into a dedicated vial, and 10 ml of scintillation cocktail (PerkinElmer Inc., Hionic-Fluor) was then added. The tritium in the concrete would gradually leach out into the scintillation cocktail. The amount of tritium in the cocktail saturated within several hours, which was certified in advance, so the vial containing the concrete piece was left for more than a day. The tritium was then measured using the liquid scintillation counter (Aloka LSC5100). This method makes it possible to directly measure tritium contamination in a piece of concrete.

Appendix 2 (heating-cooling method)

It is well known that the heating-cooling method is very effective for extracting tritium contained in concrete. In this method, a 1-g piece of concrete chipped from the concrete wall or floor was placed into a furnace and heated to 800 degrees centigrade for an hour in flowing dry air with a flow rate of 200 ml/min. The 800-degree temperature enables the extraction of not only free water but also bound water in concrete. With the heating of the concrete, tritium in the concrete was vaporized into the flowing dry air as water vapor. The air flowing out of the furnace was sent into a collection tube that was cooled in dry ice-ethanol (around -70 degrees centigrade). As a result, the water vapor including tritium in the flowing air condensed into drops of water in the cooled collection tube. After this collection procedure, about 0.5 ml of water was obtained. The collected water was put into a dedicated vial with 10 ml scintillation cocktail, and the tritium concentration was measured using the liquid scintillation counter.